Wi-Fi Sensing Application: Multipath Enhanced Device Free Localization

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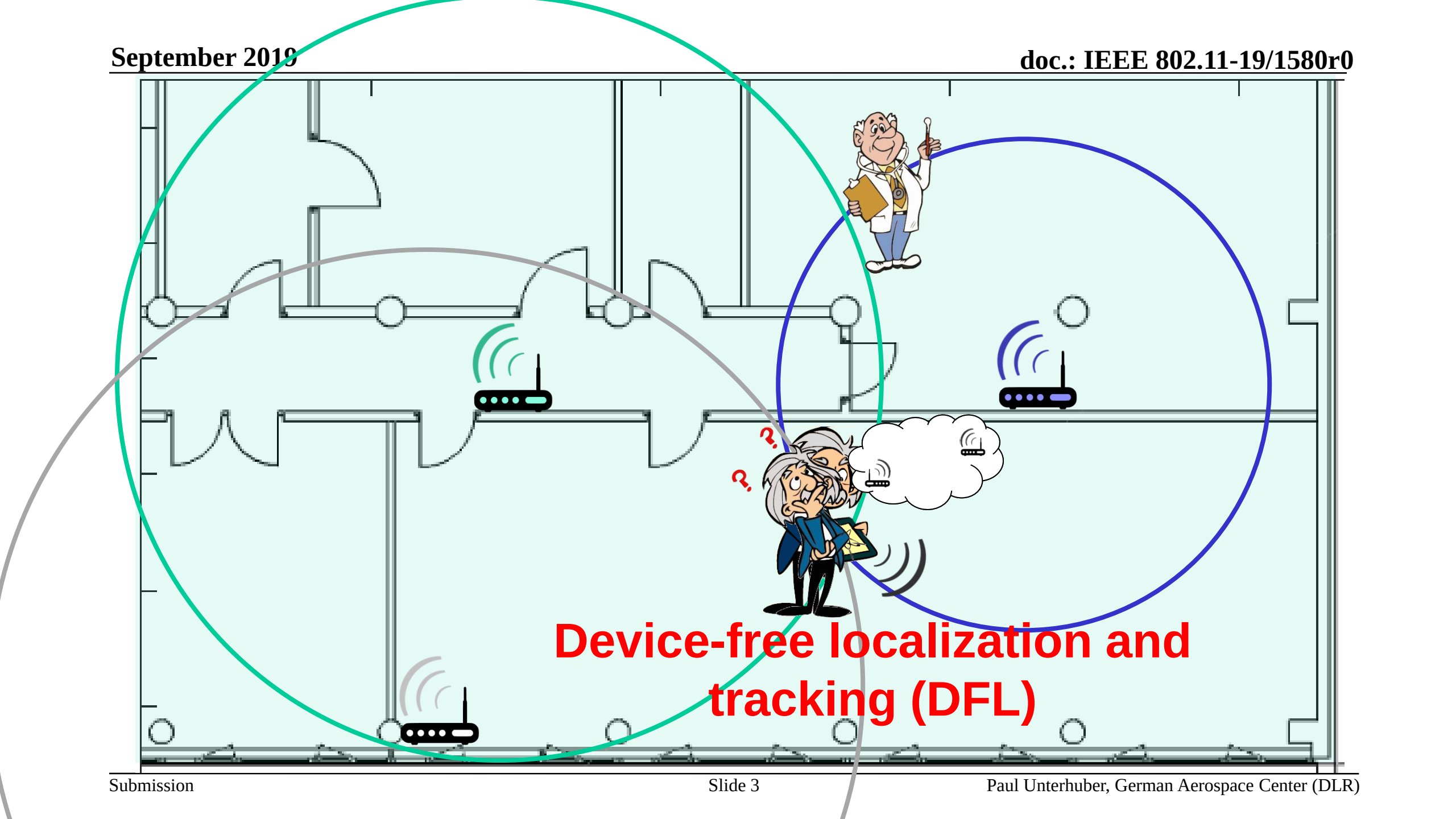
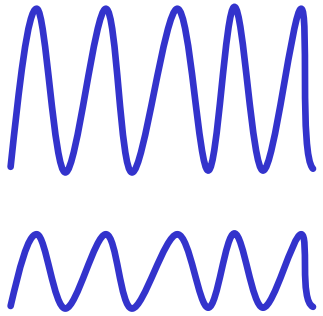
Abstract

- **Surveillance and location-aware applications**
  - smart home and old people's home
  - modern manufacturing facilities
  - even critical infrastructure
- **Physical impact on RF-signals**
  - radio tomographic imaging [1]
  - radio propagation characteristics [2]
- **Enhanced RF-based device-free localization and tracking (DFL)**
  - large bandwidth ➔ consider line of sight (LOS) and multipath components (MPCs)
  - increasing the localization accuracy
  - decreasing the high density of wireless nodes

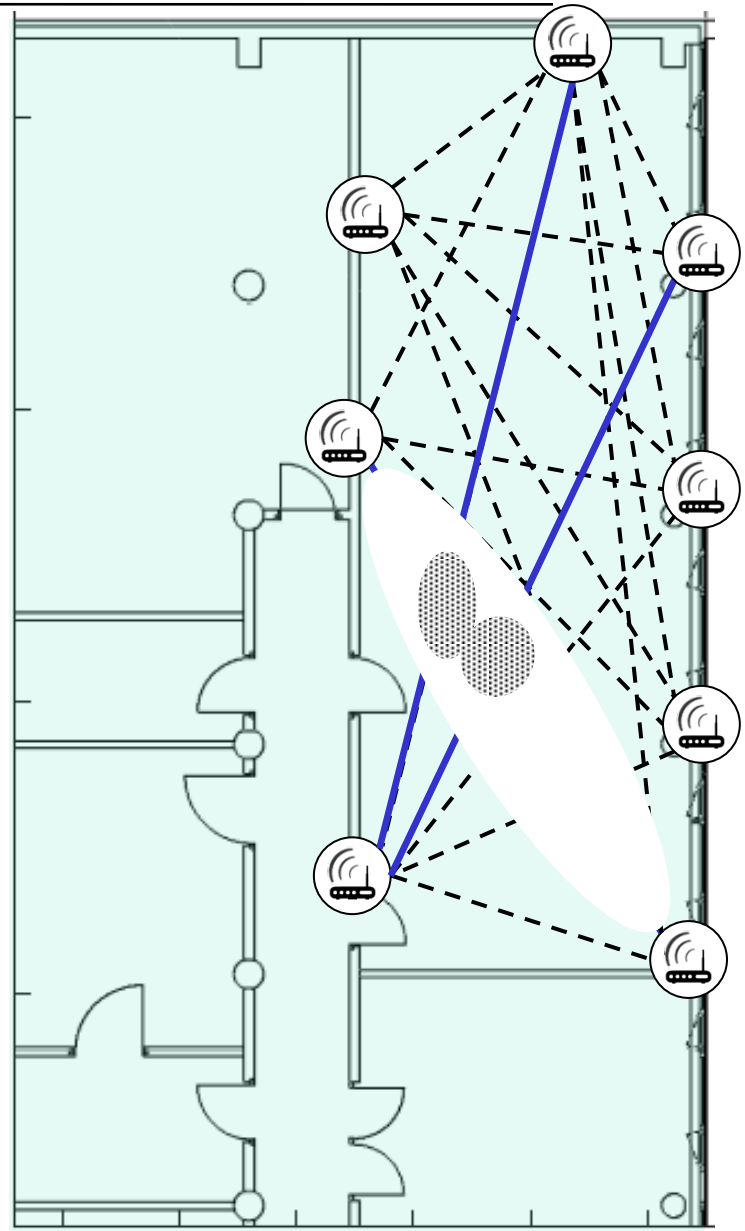

Device-free localization and tracking (DFL)

DFL Approach

- **Line-of-sight (LoS) links**
- **Received signal strength depending on**
  - path loss
  - shadowing from static environment
  - multipath fading
  - shadowing from dynamic environment

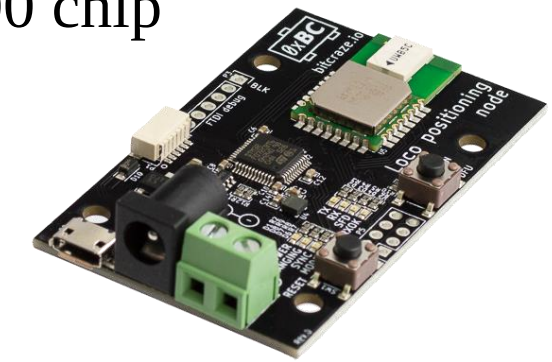


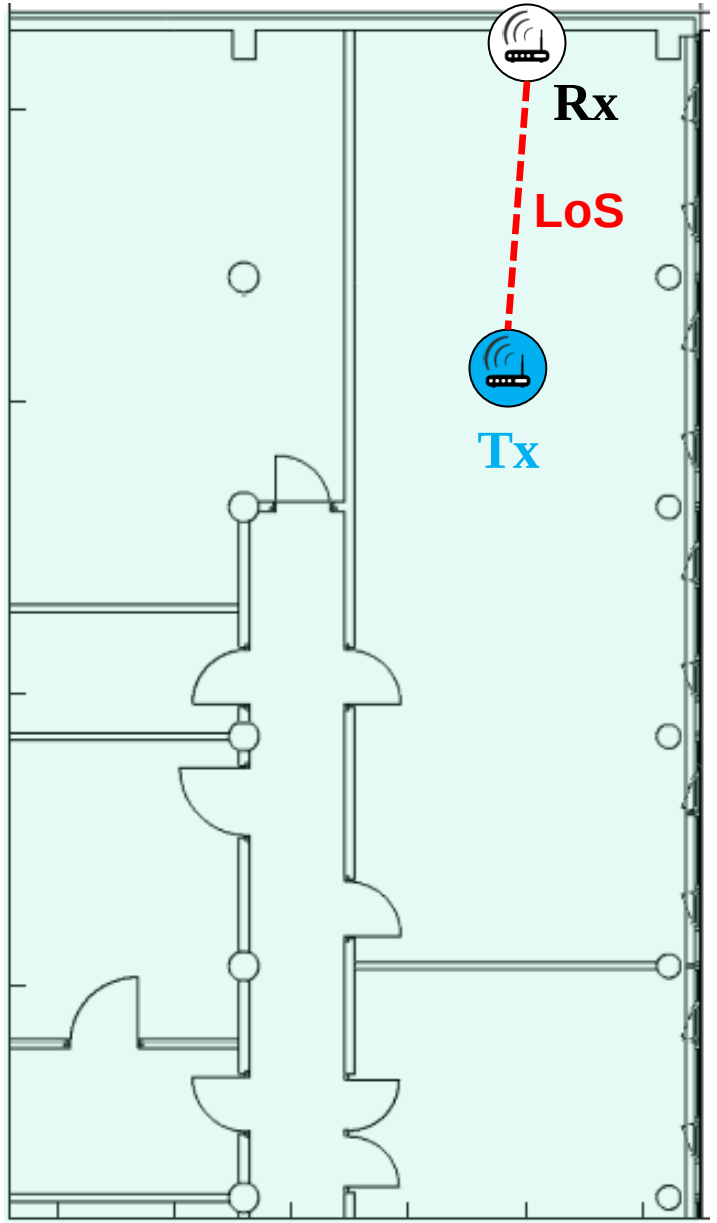
- **Bayesian filtering for localization and tracking**
- **Unambiguous localization requires dense network of wireless communication nodes**



DFL Measurements

Measurement hardware decaWave DWM1000 chip





- IEEE 802.15.4-2011 UltraWideband compliant
- 500 MHz bandwidth
- Low-cost transceiver
- Low-power consumption
- 1 Transmitter (Tx), multiple receiver (Rx)

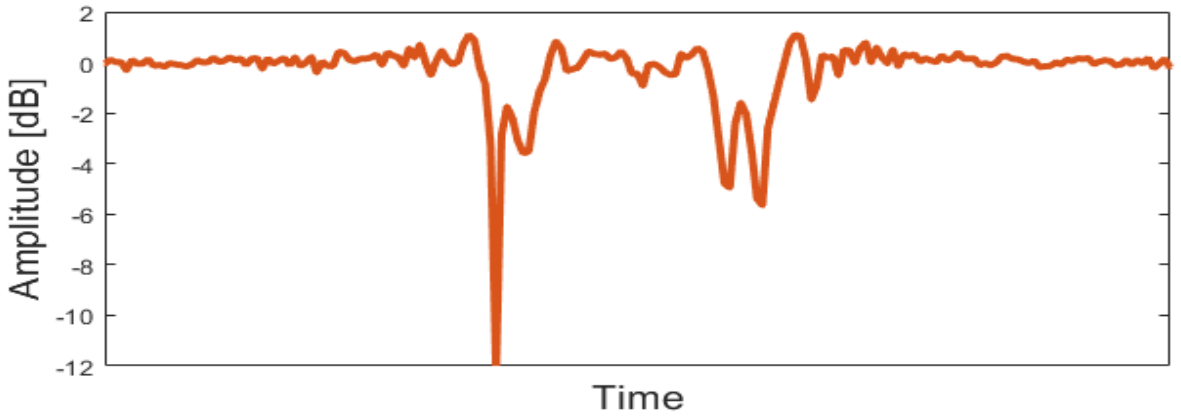
- Channel impulse response (CIR) accessible

[2]

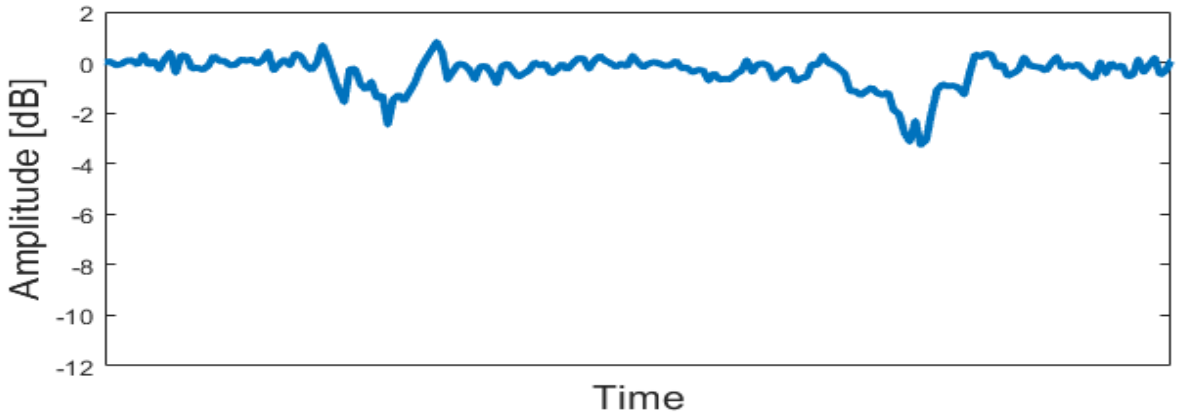
DFL LOS + MPC simple

Static multipath components (MPC) from reflection and scattering

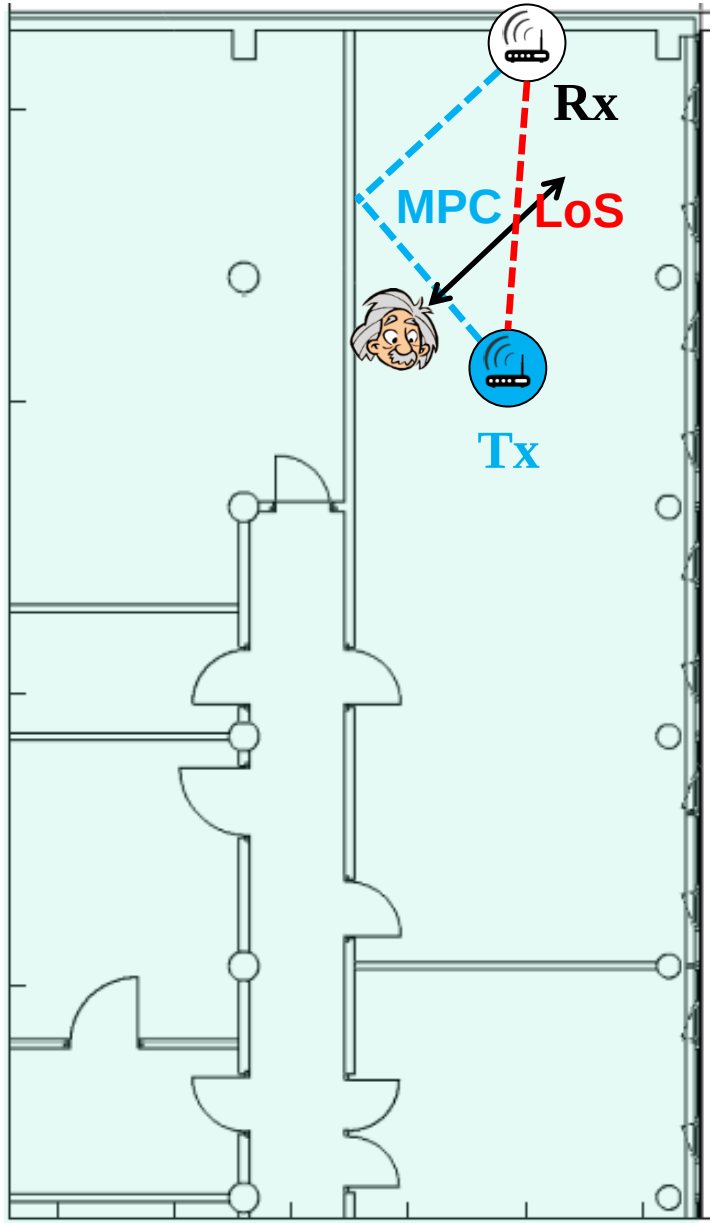
LoS link



MPC link



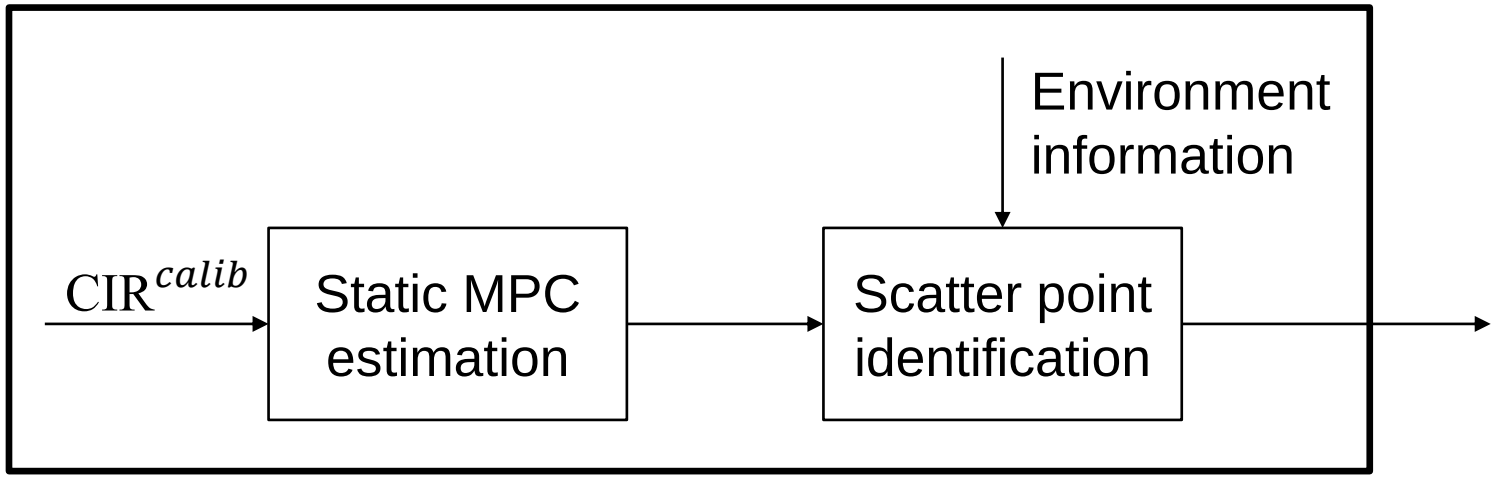
[2]

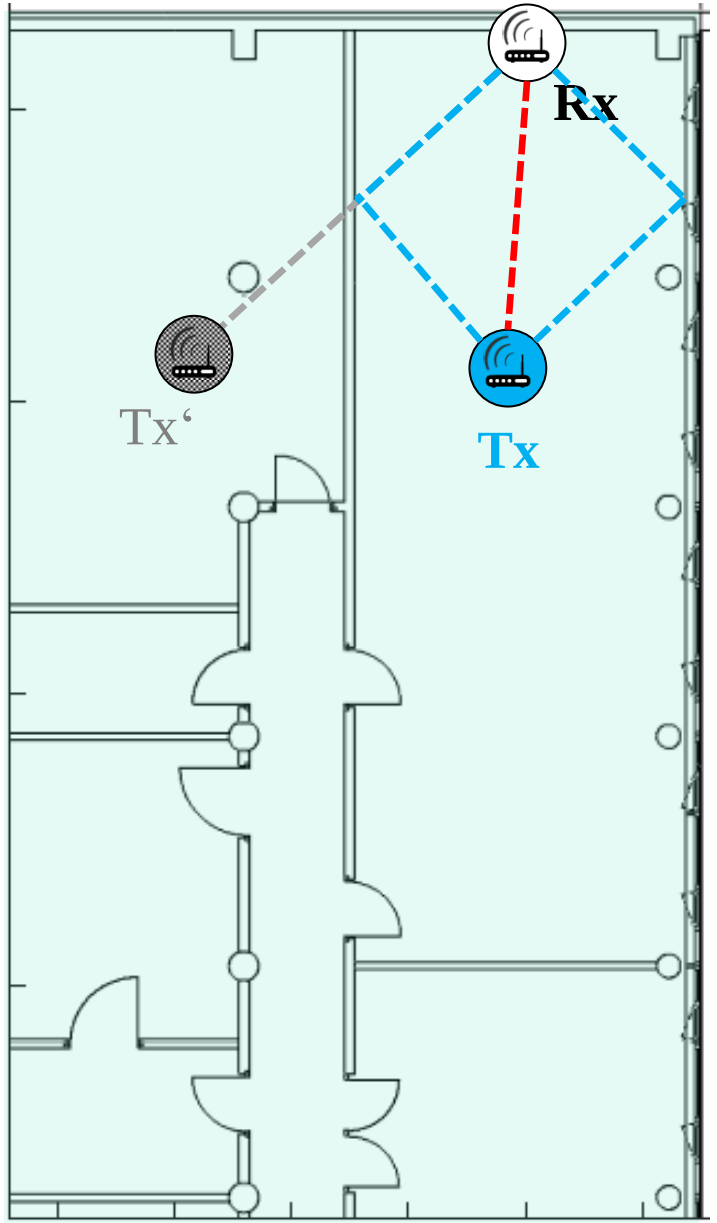


DFL LOS + MPC enhanced

Preprocessing for each pair of transmitter and receiver

Calibration





[2]

DFL LOS + MPC enhanced

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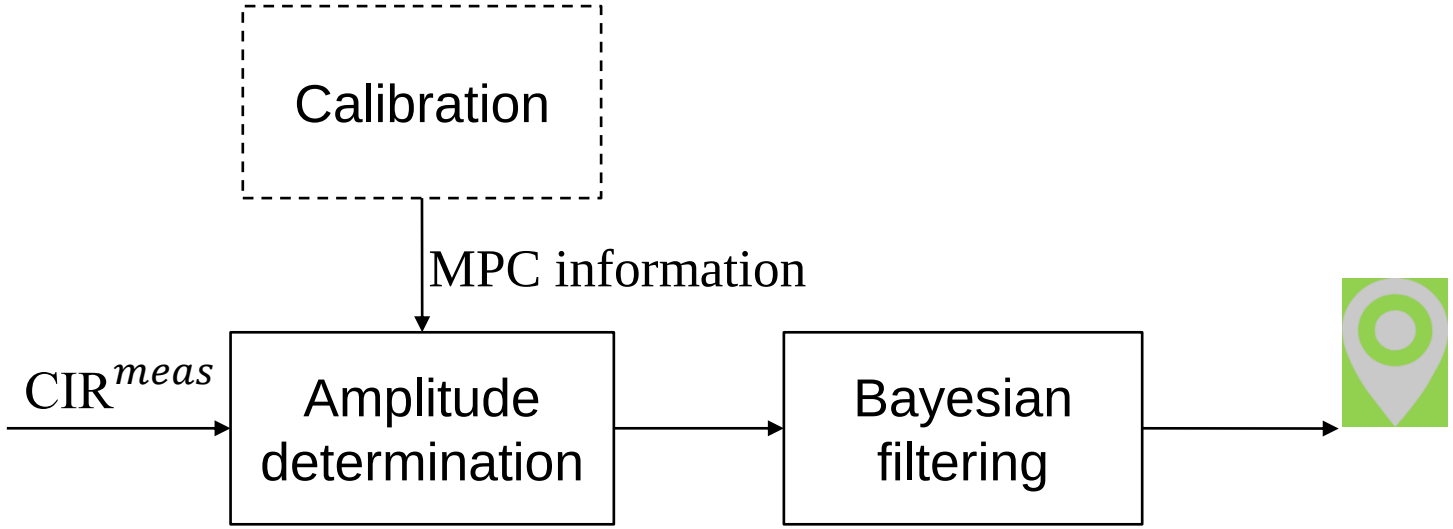
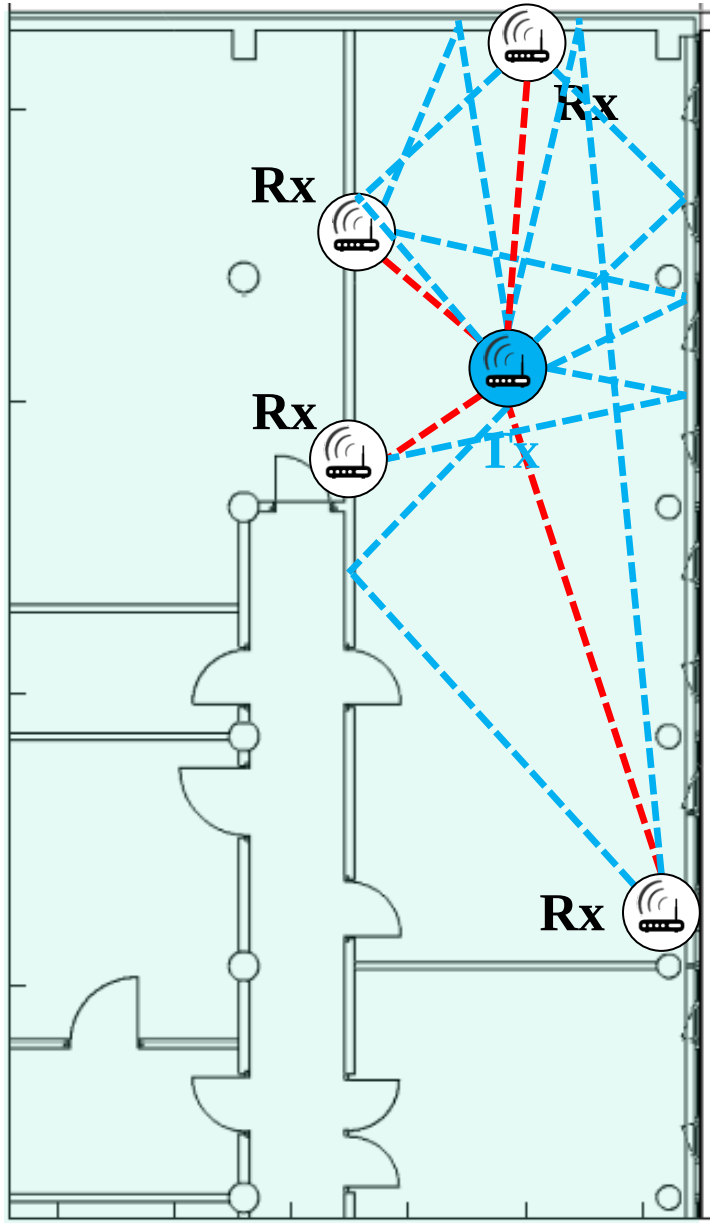
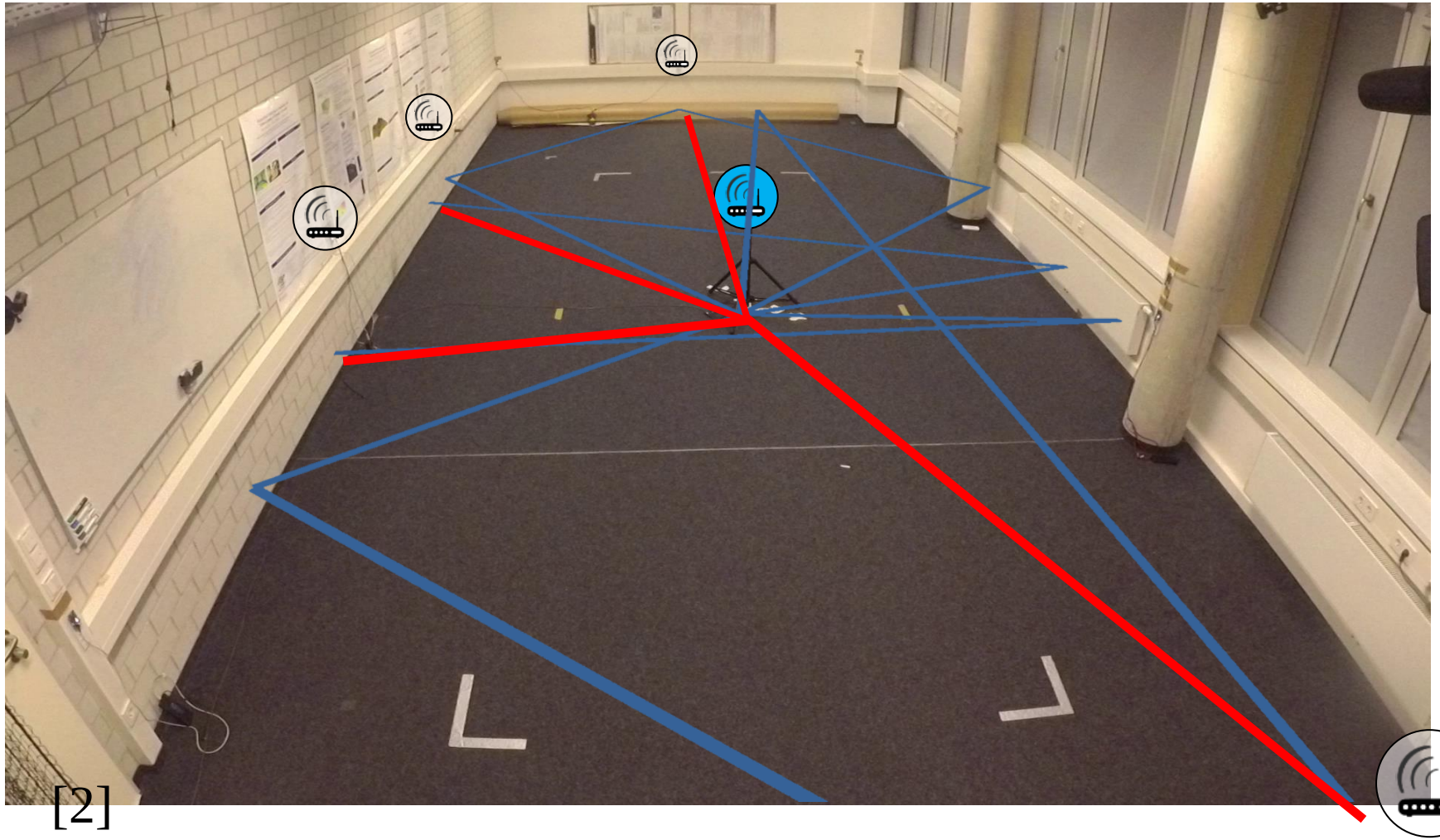
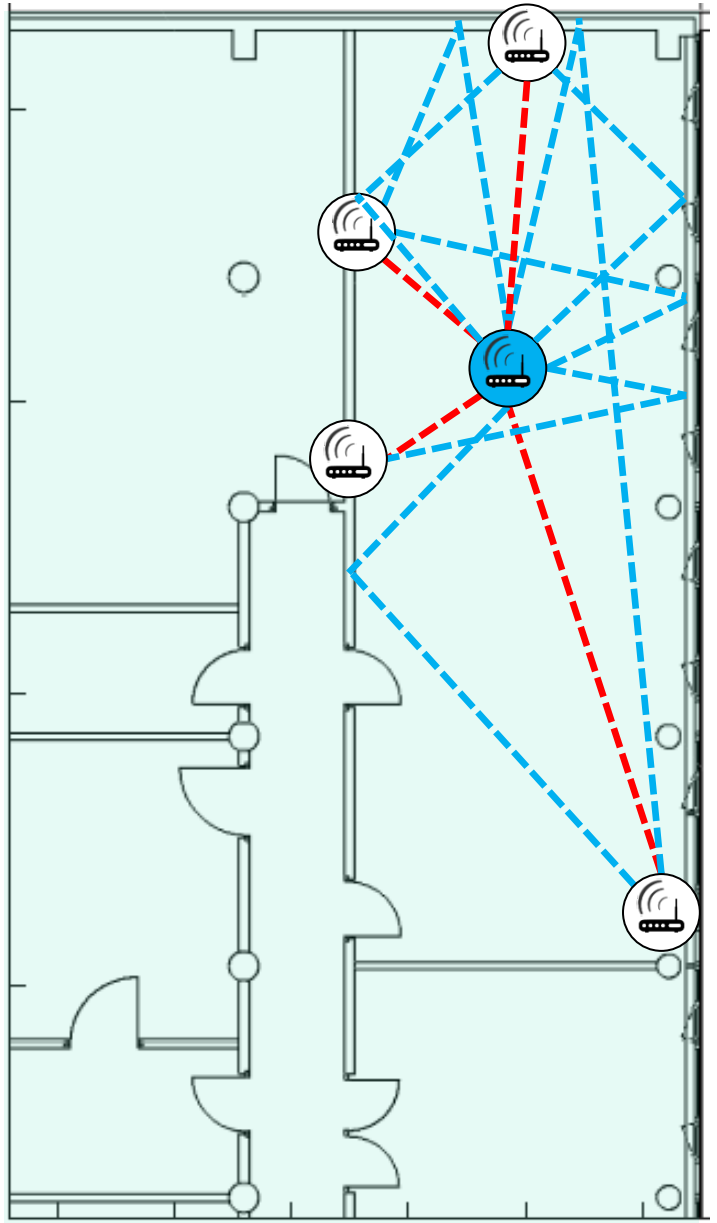




[2]

DFL LOS + MPC enhanced

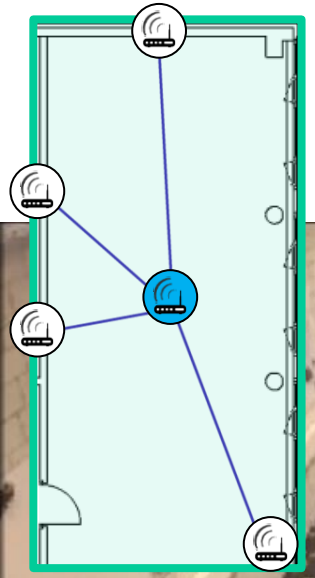




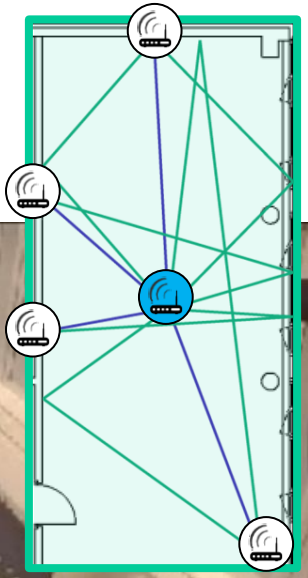
[2]

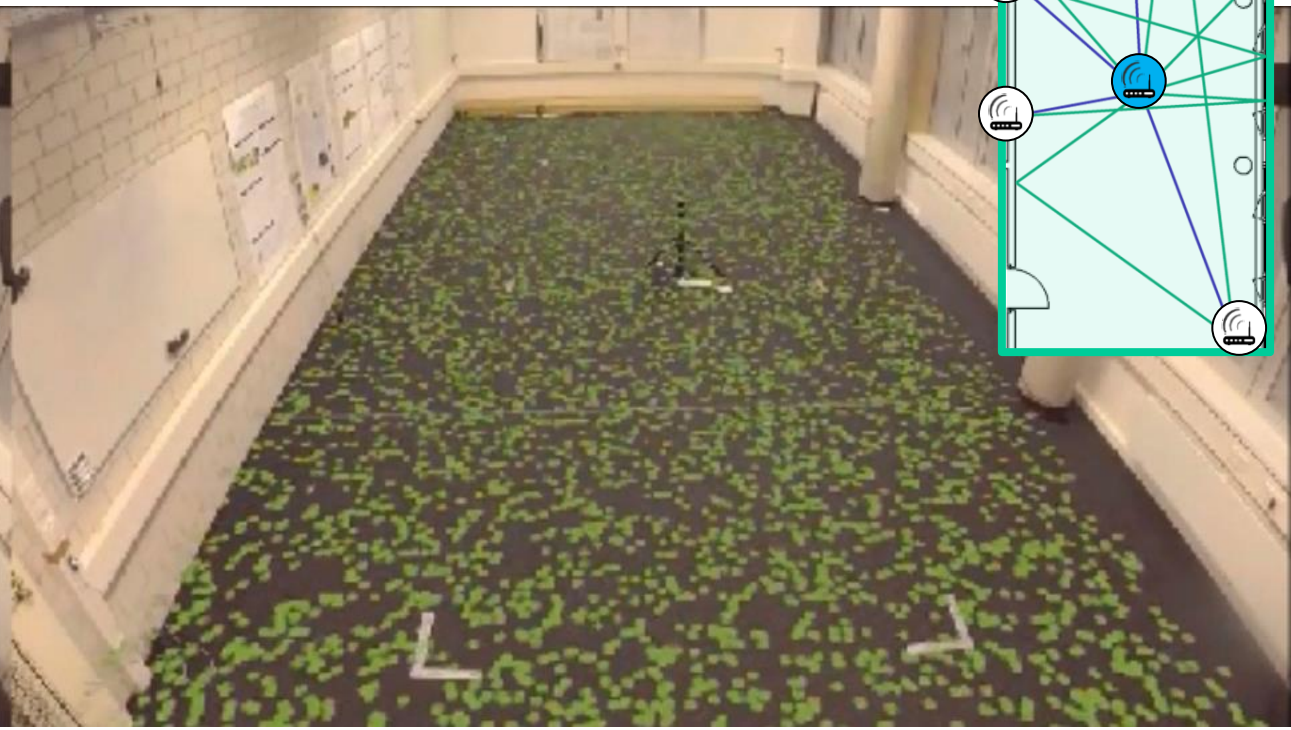
DFL Analysis

LoS only



LoS + MPC enhanced





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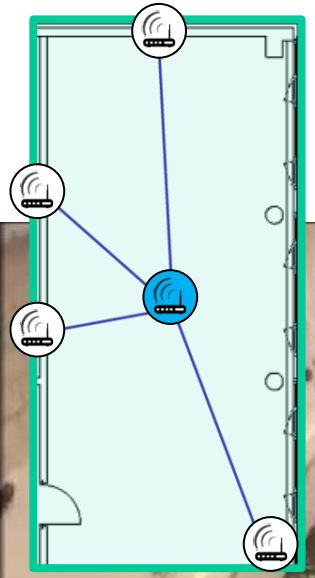
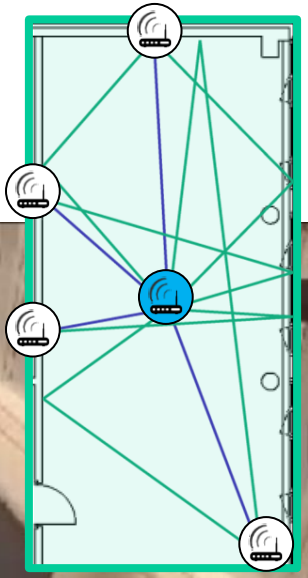


LoS + MPC enhanced



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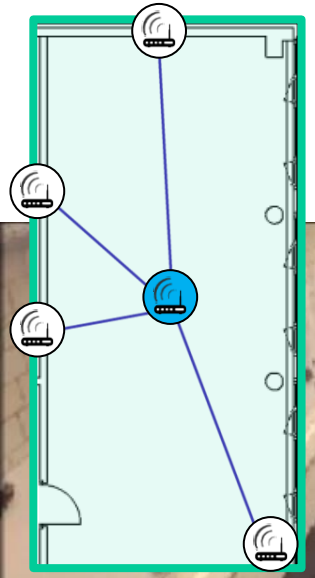
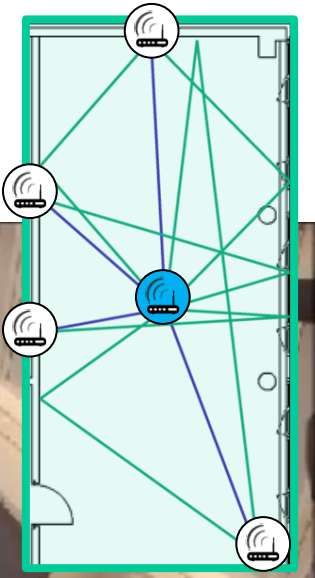


LoS only

LoS + MPC enhanced

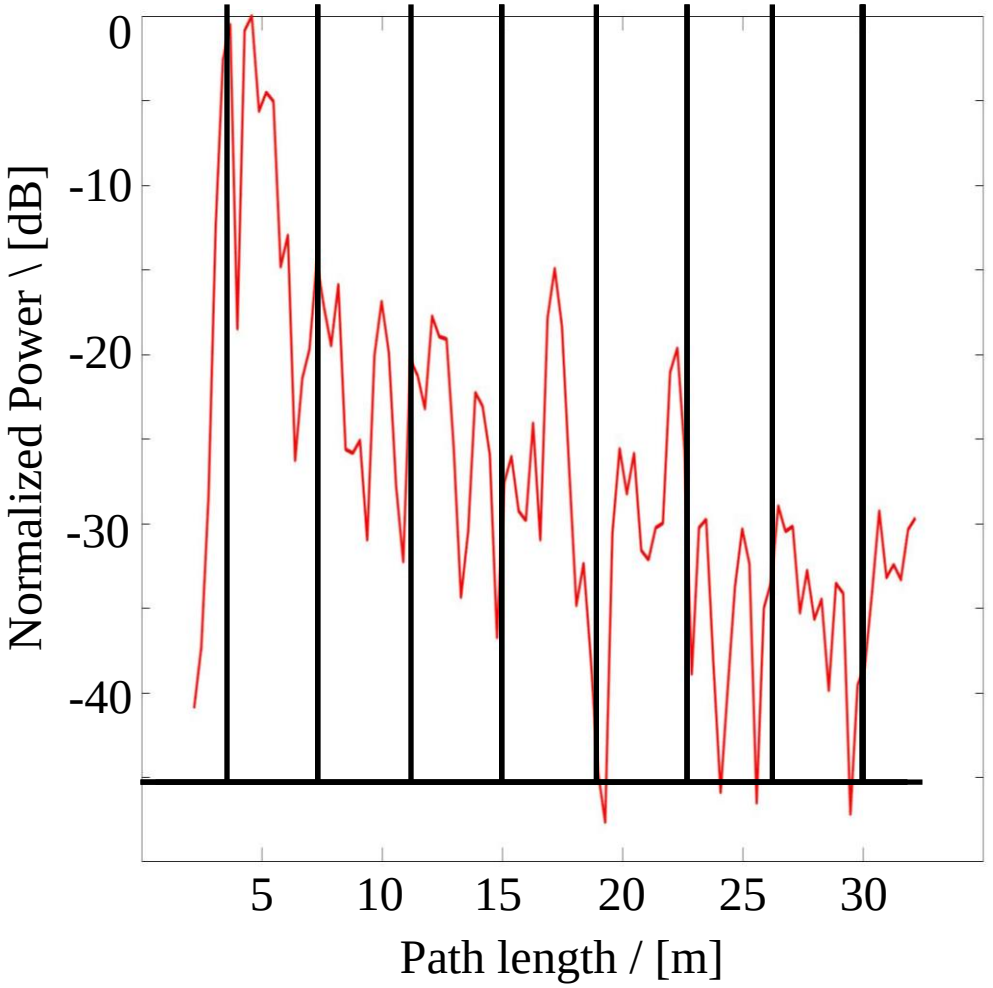


DFL Specifications

- **Calibration phase:**
  - map with floor plan, Tx, Rx positions
  - CIR
- **Tracking phase:**
  - CIR
  - low computation complexity

Comparison

Standard	Band [GHz]	Bandwidth [MHz]	Resolution [m]	SRA [m]
802.11 ay	60	8306	0.036	0.009
802.11 ad	60	1760	0.14	0.035
802.15.4	5	500	0.60	0.15
802.11 be	5	320	0.94	0.235
802.11 ac	5	160	1.88	0.47
		80	3.75	0.94
		20	15.00	3.75
802.11 p	5.9	10	30.00	7.50



Outlook on Wi-Fi Sensing for Multipath Enhanced Device Free Localization

- **Increasing accuracy with**
  - increasing bandwidth
  - increasing computational power
- **MIMO**
  - Increases number of links
  - Introduce angular information
  - Enhance calibration phase

References

[1] J. Wilson and N. Patwari, "Radio tomographic imaging with wireless networks," IEEE Transactions on Mobile Computing, vol. 9, no. 5, pp. 621-632, May 2010.

[2] M. Schmidhammer, and C. Gentner, “A Novel Approach of Passive Localization for Indoor Positioning,” ION GNSS+ 2018, September 2018.